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ABSTRACT

For each work assignment, photojournalists must decide whether to use black-and-white or color film and how to frame the picture. These decisions are considered crucial, yet little is known about how the presence of color and design complexity affect how people process the information in photographs. A study tested whether color and design simplicity affect the amount of mental effort required to make sense of a photographic image and looked at the effect of color and simplicity on viewer memory for still images. Forty photographs were videotaped in both black-and-white and color, and a set of brief captions describing each photograph was created to accompany the photographs. The matching task was constructed so that subjects saw congruent pairs 50% of the time and noncongruent pairs 50% of the time. Subjects, 52 students enrolled in a communication course at a major university, participated in the study for course credit. Twenty-six were randomly assigned to the color viewing condition and 26 were assigned to the black-and-white condition. The object was to determine if the students would match captions with photographic content for color photographs more quickly than for black-and-white photographs. Results indicated that color is an important perceptual feature that facilitates the processing of a photographic message. The implications of this result for photojournalists suggest that color film may be the proper choice when it is important to facilitate viewer processing of photographic information. Complexity manipulation did not significantly affect the mental effort required to process a photograph. (One figure is included, and 47 references are appended.) (MS)

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EFFECTS OF COLOR AND COMPLEXITY IN STILL PHOTOGRAPHS ON MENTAL EFFORT AND MEMORY

Paper submitted to the Annual Convention of the Association for Education in Journalism and Mass Communication

Theory and Methodology Division

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EFFECTS OF COLOR AND COMPLEXITY IN STILL PHOTOGRAPHS ON MENTAL EFFORT AND MEMORY

For each assignment, photojournalists must decide whether to use black-and-white film or color film and how to frame the picture. These decisions are considered crucial (Kobre, 1980; Evans, 1978), yet little is known about how the presence of color and design complexity affect how people process the information in photographs. This study tests whether color and design simplicity affect the amount of mental effort required to make sense of a photographic image. It also looks at the effect of color and simplicity on viewer memory for still images.

Color

Perception research has examined color as a visual feature that is analyzed immediately by a specialized set of receptors that map the color information in a specific area of the brain (Zeki, 1976). This information is then integrated with other basic features such as shape, size and location in order for the image to be perceived (Treisman, 1977; Treisman & Gelade, 1980; Treisman, Sykes & Gelade, 1977). Objects in any visual field are fixated more quickly on the basis of color than on the basis of size or shape (Williams, 1966). Arnheim (1974: 330) suggests that color is fundamental to correctly perceiving the information presented in mediated messages: "An audience looking at a black-and-white film is often at a loss to identify the strange food the actors have on their plates .... When added to dimensions of shape, even a few crudely applied color dimensions will greatly enrich visual disrimination."

Most media researchers who have examined color effects on memory and comprehension have used primarily television messages (Scanlon, 1967, 1970; VanderMeer, 1954). These studies suggest that color adds information to a pictorial message, facilitates the identification of objects, and may increase image memorability. Early studies of black-and-white vs. color television messages suggest that color hinders learning of central information and attracts viewers to irrelevant details such as color of hair or style of clothing (Scanlon, 1967, 1970). These studies were conducted when color television was a new phenomenon. More recent studies have found that colored visual messages elicit greater learning and are better remembered than black-and-white messages (Franken, 1977; Power, 1978; Reid, Beveridge, & Wakefield, 1986).

This study defines color as a perceptual feature that, in conjunction with shape, size, location, brightness, line, angle and contour, describes the physical aspects of the visual images found in still photographs.

Complexity

Houston Post photographer Mike Boddy (Gilbert, 1986:7) says that the best photographs are "simple pictures, where the elements are clean and well-defined and there aren't too many of them." Visual simplicity (i.e., complexity) has been defined as the degree of randomness or entropy among the luminance contours of an entire visual field (Watt & Welch, 1983). This Information Theory definition is measured using a mathematical equation. Complexity has also been conceptually defined for the visual channel of television messages as the amount of noncontent information present (Schleuder, Thorson, & Reeves, 1987, 1988; Thorson,

Reeves, & Schleuder, 1985, 1986). In experiments that use this definition, complexity is measured by asking pretest subjects to rate the amount of information presented in each message. Pretest subjects compared the messages to a standard and estimated the complexity on a 100-point scale. The complexity level of the visual image standards was determined by using a coding scheme derived from Information Theory. Studies that compare subject ratings of complexity to Information Theory measures have found the two measures highly correlated (Berlyne, 1974; Cupchik & Berlyne, 1979; Heinrichs, 1984; Nicki, 1972, 1981; Vitz, 1966).

This study conceptualizes photographic complexity in a way similar to that of Schleuder et al. and Thorson et al. Complexity is defined as the amount of information present in a photograph. High and low complexity were determined by asking a large group of pretest subjects to rate 100 photographs on a scale of 1 (low complexity) to 100 (high complexity).

Mental effort and the photograph-caption matching task

To determine if color and complexity affect how the information in still photographs is processed, a measure of mental effort called the picture-word matching task was used. In this study we refer to this task as the photograph-caption matching task since we use published photographs and two- or three-word captions rather than line drawings and nouns. Use of this task rests on the assumption that mental processing takes time (Posner, 1978).

The photograph-caption matching task requires subjects to look at a photograph, read a caption, and decide if the caption describes the photograph. The time it takes for the viewer to press a button marked congruent or another one marked incongruent indicates how much mental

effort is required. It is assumed that a longer response time indicates a higher amount of mental effort expended (Sternberg, 1969).

Color photographs are expected to require less mental effort than black-and-white photographs because color has been shown to facilitate object discrimination and play a key role in visual search (Treisman, 1977; Treisman & Gelade, 1980; Treisman et al., 1977; Williams, 1966). It should take less time for people to perceive a color scene so that meaning level processing should occur more rapidly than for a black-and-white scene, and choice reaction time responses to the photograph-caption matching task should be faster for color photographs.

Complex photographs are expected to require more mental effort than simple photographs. As practicing news photographers note, a more complex photograph seems to take more time to understand. The more elements in a photograph, the harder it is to grasp the "simple meaning" of the image. Complex photographic information is predicted to move more slowly to the meaning-level stage of processing and produce slow response times to the photo-caption matching task.

Memory for information in photographs

Predictions for the effects of color and complexity on memory derive from levels-of-processing theory. The basic model, proposed by Craik and Lockhart (1972), assumes that information processing takes place at two levels. The first is the perceptual level, where sensory features such as color, lines, angles, brightness, tone, and pitch are analyzed. The second is the conceptual level where higher-level operations, such as item recognition, comprehension, problem solving, and decision-making take

place. Craik and Lockhart (1972) predicted that the more rapidly a piece of information moved from the perceptual to the meaning stage of processing, the more meaning processing it would receive and the better it would be remembered. Use of slightly different stimuli shows, however, that memorability also increases when a piece of information receives more perceptual processing (Gardiner, Craik, & Bleasdale, 1973; Gotz & Jacoby, 1974; Kolers, 1973, 1975; Jacoby & Craik, 1979).

A visual recognition test is used as an indicator of memory for photographic stimuli. Recognition is theoretically defined as a feeling of "familiarity or identification" and the strength of the feeling is assumed to vary according to the degree of processing performed on the stimulus. The amount of processing given a stimulus can vary according to amount of time and attention given the stimulus (Glass & Holyoak, 1986). This study tests whether the amount of complexity in a photograph or the presence of color leads to greater recognition for still photographs.

Recognition testing has two essential components: a study set and a test set. The study set is comprised of the stimuli the subject is to remember and the test set is comprised of a mixture of stimuli from the study set and distractor items. Distractors are items the subject has not seen in the study. Subjects are asked to examine the study set and then identify the items in the test set that they have seen before.

Memory results from studies using photographs and complex line drawings indicate that color stimuli are better remembered than black-and-white stimuli (Bousfield, Esterson, & Whitmarsh, 1957; Denis, 1976; Franken, 1977) while other results show that black and white is better remembered than color or show no differences at all (Paivio, Rogers, & Smythe, 1968; Wicker, 1970).

It is predicted that color photographs will require less mental effort than black-and-white photographs to be encoded at the perceptual level. Thus, color photographs should be more memorable than black-and-white photographs (Craik & Lockhart, 1972). This would be indicated by higher recognition accuracy scores for color photographs.

Memory results for studies looking at visual complexity also show a variety of results. Loftus and Bell (1975) found that photographs were better recognized than either sparsely detailed or highly detailed line drawings of the same subject. Other studies show similar results (Daw & Parkin, 1981; Loftus & Kallman, 1979). Some studies, however, have found that outline drawings are better recalled than highly detailed line drawings (Coulter, Coulter, & Glover, 1984; Ritchey, 1982) and studies of visual recognition in television commercials (Schleuder et al., 1987, 1988; Thorson, et al., 1985, 1986) show that people remembered visually simple commercials better than visually complex commercials.

Simple photographs are predicted to require less mental effort at the perceptual level. Thus, they are expected to move more quickly to the meaning level of processing and thus be more memorable than complex photographs (Craik and Lockhart, 1972). This would be indicated by higher accuracy scores for simple photographs.

Both memory and mental effort effects of color and complexity will be investigated using a 2 (color vs. black-and-white) x 2 (simple vs. complex) mixed factor design. Color will be a between subjects factor to increase experimental control. The same photographs will be used in each group, however, one group will see the photographs in color, the other in black and white. Complexity will be a within subjects factor and will be determined by having a large group of pretest subjects rate complexity

using Stevens' (1972) magnitude estimation method. The complexity measure will thus be based on audience perceptions, not through mechanical information estimation procedures. A choice reaction time task that involves measuring how long viewers take to correctly match a caption to a photograph will be used as an indicator of mental effort. A visual recognition task that tests viewers' ability to remember portions of photographs will be used as an indicator of memory.

METHODS

Subjects

A total of 52 students enrolled in a communication course at a major university participated in the study for course credit. Twenty-six were randomly assigned to the color viewing condition and 26 were assigned to the black-and-white condition.

Stimulus Materials

A 40-photograph stimulus set was created by clipping all high-quality color photographs larger than 3" x 3" from the 1985 and 1986 issues of eight popular magazines[1]. Approximately 33 advertisements, 33 news features, and 33 photo-illustrations were randomly selected from the 152 photographs collected and shown to a large group of students who were asked to rate the complexity of the photographs on a scale of one to 100. Students were told to think of complexity as "the amount of information present in a photograph," and they were shown an example of high complexity (a crowded street scene) and low complexity (a man's head and shoulders shown against a white background) as anchors for their

judgments. Mean scores were calculated for each photograph and the 20 highest and 20 lowest scoring photographs were selected for the experiment.

Three randomized orders of the 40 photographs were prepared and videotaped in both black-and-white and color. Each photograph was displayed on a light-brown cardboard background, videotaped, and edited until it appeared on tape for exactly three seconds. Warning tones were placed on the tapes 1/2 second before the photograph appeared to orient subjects to the video screen. Five seconds of TV black were recorded between each photograph.

A set of two- or three-word captions describing the subject of each photograph was created to accompany the photographs. The photo-caption matching task was constructed so that: (1) subjects saw congruent photo-caption pairs 50% of the time and incongruent pairs 50% of the time; and (2) half the subjects saw a given photograph with a congruent caption and the other half saw it linked with an incongruent caption.

To create a totally counterbalanced design, each photograph had to be seen equally often in both congruent and incongruent conditions. Thus, 50% of the captions on the master list were randomly reassigned to photographs they did not correctly describe, creating the incongruent pairs needed for the test (no caption was allowed to appear within five places of the photograph it originally described). The other half of the captions stayed with the photographs they described and became the congruent pairs. A second list was created by reversing the treatments described above. The captions used for the congruent pairs of the stimulus set were reassigned to incorrect photographs and the incongruent captions in the list described above were returned to their original photograph mates.

Experimental Design and Dependent Measures

Color was a between-subjects variable with two levels (color and black-and-white) and complexity was a within-subjects variable with two levels (simple and complex). Choice reaction time to a photograph-caption matching task and a visual recognition test were the dependent measures.

In this particular choice reaction time task subjects compared a photograph with a caption and indicated by striking a key labeled congruent or a key labeled incongruent whether the photograph and caption matched.

To measure recognition accuracy subjects viewed 20 portions of photographs they had seen previously, randomly mixed with 20 distractor portions (taken from photographs similar, but not identical, to those used in the photo-caption task) and indicated whether they recognized the portion or not. Half the stimulus photograph portions were from "simple" and half were from "complex" photographs.

Numerous studies show that people are very good at recognizing visual materials. Standing (1973), for instance, found that, after seeing 10,000 different pictures, people still scored an average of 73% correct in an immediate recognition test. To limit ceiling effects four manipulations were made: 1) an area equal to 20% of the surface area of the photograph was used; 2) a section at horizontal center and just below vertical center was used -- the section was determined with the aid of a 5-section overlay designed for the dimensions of each photograph with each section equal to 20% of the photograph's surface area; 3) each photograph filled the video screen, regardless of its original size; and 4) each photograph portion was presented to subjects for only 1/15 sec.

Procedure

Subjects were randomly assigned to view either color or black-and-white photographs, one of the three videotape orders, and one of the two caption orders. A practice session was used to familiarize them with every part of the test. Three photo-caption pairs were shown along with a practice recognition test, consisting of three photograph portions.

Each subject was shown the 40 photo-caption pairs and asked to indicate whether or not the caption matched the photograph. They viewed the photograph for three seconds, then viewed a caption on an adjacent computer screen. Their right hands rested on the lower-left corner of the keyboard with index fingers extended and equidistant between two keys. (Left-handed subjects were allowed to use their left hands). Subjects were told to hit the left key (marked "C") for congruent when the caption matched the photograph or the right key (marked "I") for incongruent when the caption did not match the photograph. They were told to respond as quickly and accurately as possible.

After viewing all 40 photographs, subjects were told they would see 40 portions of photographs for a very brief time and should hit the "y" key on the keyboard if they recognized the portion or the "n" key if they did not. They were told to watch the screen carefully as the portions appeared briefly. Throughout the experiment subjects maintained a constant viewing distance of 3 feet (from the television monitor) and 2 1/2 feet (from the computer screen).

Apparatus

Photographs were viewed on a 20" Panasonic video monitor (CT-1010M). Responses were made on an IBM XT Personal Computer keyboard. Presentation, timing, and recording of the responses were controlled by the IBM XT.

RESULTS

Photo-caption matching reaction-time

A 2 (color vs. black-and-white) x 2 (simple vs. complex) mixed factor analysis of variance was used to analyze the reaction time scores. Only correct responses (92% of total responses) were included in the analysis. Figure 1 shows that, for both simple and complex photos, the mean reaction time was significantly faster for the color group than for the black-and-white group $F(1,50) = 4.35$, $p < .05$. The mean reaction time in the color group was 1.32 secs. while the mean reaction time in the black-and-white group was 1.46 secs.

Recognition accuracy

Subjects correctly answered "yes" to an average of 47% of the 20 photographs they had seen earlier in the experiment, although they were somewhat better at identifying the 20 distractor photographs (65% accuracy rate).

A planned comparison of simple and complex photos that were previously seen (20 total) collapsed across levels of color produced a main effect for complexity $F(1,50) = 7.42$, $p < .01$. The mean accuracy score for

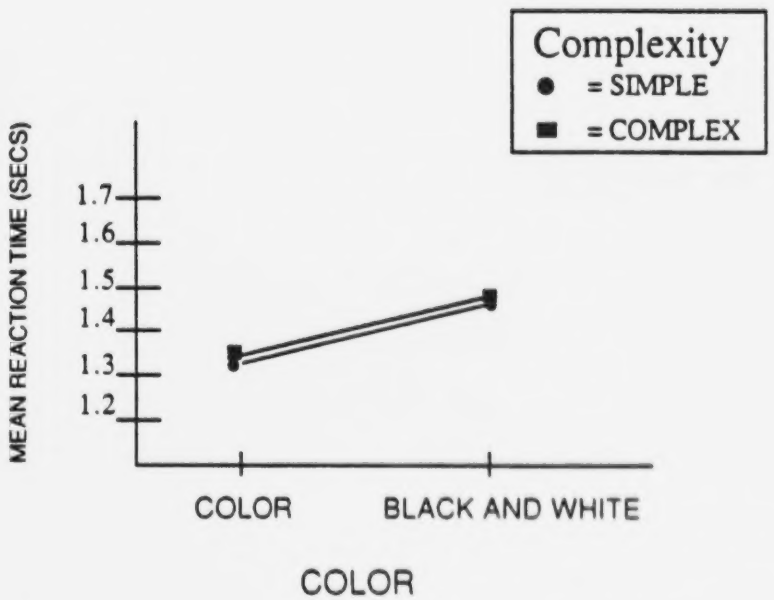

Figure 1: Mean reaction times scores as a function of photograph color and complexity.

simple photographs was 4.23 out of 10 and the mean for complex photographs was 5.10.

Planned comparisons were also used to compare subjects' accuracy scores on simple and complex photographs within the color and black-and-white viewing conditions separately. A significant difference was found in the color condition, $F(1,25) = 9.69$, $p < .02$. The mean for simple photographs was 4.15, out of 10, and the mean for complex photographs was 5.35. No significant difference was found for the black-and-white viewing condition.

DISCUSSION

Four questions guided this study: (1) Do color photographs require more mental effort to process to the point at which meaning can be extracted? (2) Are color photographs more memorable? (3) Are simple photographs processed more quickly, as suggested by the intuitive observations of photographers? (4) Are simple photographs more memorable?

People were able to determine if captions matched photographic content for color photographs more quickly than for black-and-white photographs. This result indicates that color is an important perceptual feature that faciliates the processing of a photographic message. The implications of this result for photojournalists is that color film may be the proper choice when it's important to facilitate viewer processing of photographic information.

The complexity manipulation did not significantly affect the mental effort required to process a photograph. This suggests a number of

possibilities. Perhaps the complexity manipulation was not strong enough. These photographs, which all came from the same type of media, may reflect a limited scope of pictorial possibilities. The viewing time may have been too long to show an effect. It is known that people can identify the subject of a picture in as little as 113 msec and Potter (1975) estimates that it requires several hundred milliseconds more time to understand some of a picture's message and structure. Thus, the viewing time for photographs in this study could have been reduced to less than one second, resulting in more evident differences between the complex and simple conditions. It may also be that unless subjects are directed to attend to every element in a photograph only the most critical features will be attended to. Only a small amount of information may be required to answer a caption-matching question, and thus the complexity of a photograph would show no effect.

The null finding for complexity could also be seen as a challenge to the commonly held assumption that media photographs must be graphically simple to be quickly understood. While graphic simplicity may help attract reader attention, it may not necessarily enhance comprehension of the photographic message. No conclusions can be drawn from a null finding but this finding suggests more research into the nature of visual complexity is necessary.

Subjects correctly recognized 47% of the photos they had seen before. Analysis of this data shows that for previously seen photographs, complex images were remembered significantly better than simple images. Given this result, it is reasonable to assume that greater photographic detail increases image memorability. It also suggests that still photographs may be quite different from television images, as complexity

showed the opposite effect in Schleuder et al.'s (1987, 1988) and Thorson et al.'s (1985, 1986) studies of television commercials.

The results of this study challenge the commonly held feeling of most photographers that simple photograph design leads to better viewer understanding of the information in the photograph and higher levels of memorability. It also suggests that color is an important feature for photographers to consider using when viewer comprehension is their goal.

FOOTNOTES

1) Magazines used in the study were: *Life, Newsweek, Rolling Stone, Sports Illustrated, Texas Monthly, Time, U.S. News & World Report,* and *Vanity Fair.*

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